

PHENOLIC DIVERSITY AND ANTIOXIDANT CAPACITY OF ALGERIAN FIG (*FICUS CARICA* L.) FRUITS

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Abstract

This study investigates the phytochemical composition and antioxidant activity of fruit extracts from four Algerian varieties of *Ficus carica* L., including figs and Breba figs (Bakor). Samples were collected from two bioclimatic regions: Lahmar (desert) and El Bordj (semi-arid). Methanolic, aqueous decoction, and infusion extracts were analyzed for total polyphenols, flavonoids, anthocyanins, and condensed tannins using spectrophotometric methods. Antioxidant capacity was evaluated through DPPH, FRAP, phosphomolybdenum, H₂O₂ scavenging, and β -carotene bleaching assays. Methanolic extracts, particularly from Lahmar, exhibited the highest polyphenol (10.4 ± 0.48 mg GAE/g) and flavonoid contents (1.69 ± 0.15 mg QE/g), with strong antioxidant activity (DPPH IC₅₀ = 1.91 mg/ml). HPLC revealed key phenolics including gallic acid, catechin, and rutin. Results indicate a positive correlation between phenolic content and antioxidant potential, influenced by origin and fruit type. These findings highlight the valorization potential of Algerian fig varieties as natural antioxidant sources.

Introduction

The common fig tree (*Ficus carica* L.), an economically and ecologically important species in Algeria, where it represents one of the major fruit crops (Chouaki *et al.* 2006). Its traditional use reflects its richness in bioactive secondary metabolites. Oxidative stress contributes to several chronic diseases, including neurodegenerative and cardiovascular disorders, diabetes, and cancer (Aseervatham *et al.* 2013). Growing concerns about the safety of synthetic antioxidants have increased interest in natural alternatives, particularly plant-derived sources (Kicel *et al.* 2016, Liu and Yang 2018). Despite the importance of the fig cultivation in Algeria, the phenolic composition and antioxidant potential of local varieties, particularly those from western and southwestern regions, remain insufficiently characterized. Therefore, this study evaluated the phenolic composition and antioxidant activity of four Algerian fig varieties and examined the effects of fruit type and geographical origin.

Material and Methods

The fruits of four *Ficus carica* L. varieties, (2 figs and 2 Breba figs) were collected from May to September 2017 in Lahmar (Bechar, desert climate, var.1 Breba fig, var.2 fig) and El Bordj (Mascara, semi-arid Mediterranean climate, car. 3 Breba fig, var. 4 fig). Fruits were dried at 40°C for 48 h and powdered. Methanolic extracts were prepared by ultrasound-assisted extraction of 20 g powder in 200 ml of methanol (Mahmoudi *et al.* 2013), while aqueous extracts were obtained by decoction or infusion of 50 g powder in 500 ml distilled water (Kraft and Hobbs 2004). Twelve extracts (4 methanolic, 4 decocted and 4 infused) were prepared, dried, and stored at 4°C. Extraction yield were determined according to Sembiring *et al.* (2018). Total polyphenols,

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flavonoids, anthocyanins and condensed tannins were determined spectrophotometrically in triplicate using Folin-Ciocalteu (El-Haci *et al.* 2012), AlCl_3 (Hebi and Eddouks 2015), pH-differential (Lako *et al.* 2007, Ercisli *et al.* 2012) and vanillin (Mahmoudi *et al.* 2013) methods, respectively. Antioxidant activity was assessed in triplicate using phosphomolybdenum (Prieto *et al.* 1999), DPPH (Sanchez Moreno *et al.* 1998), FRAP (Doukani *et al.* 2014), H_2O_2 -scavenging (Kataki *et al.* 2014) and β -carotene bleaching (Barros *et al.* 2007) assays, with ascorbic acid as reference antioxidant. Results were expressed as appropriate IC_{50} , EC_{50} or percentage inhibition values.

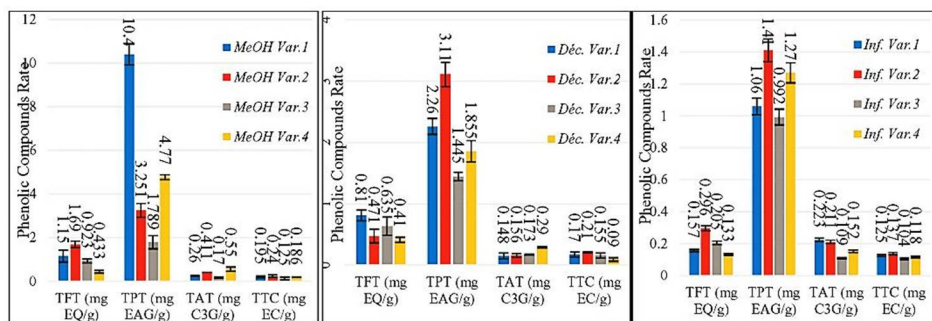
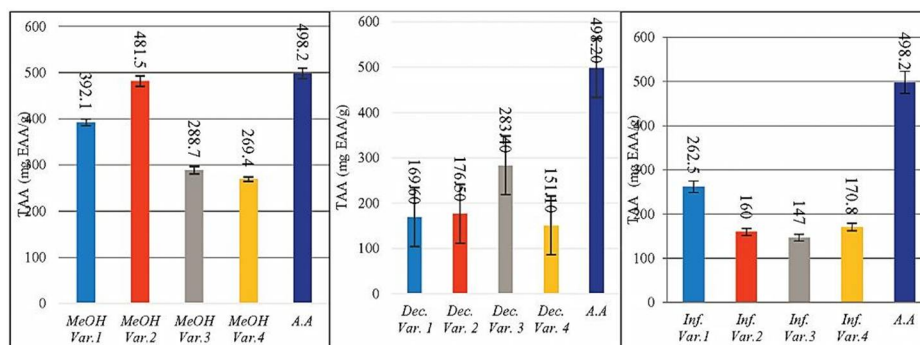
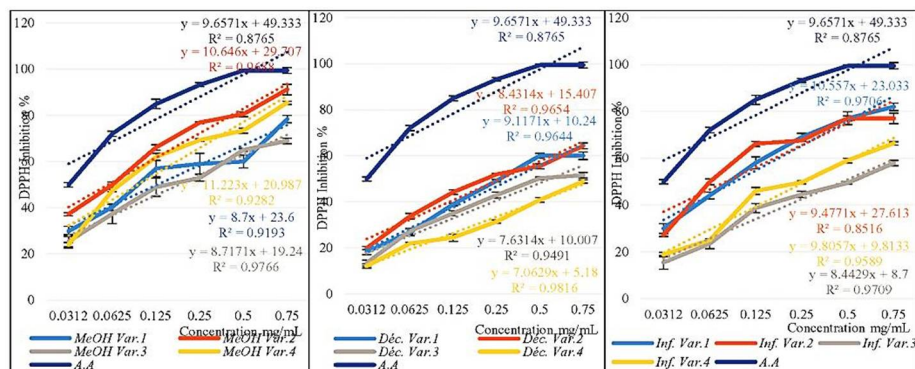
Phenolic compounds were analyzed by HPLC with 1% acetic acid in water and methanol as mobile phases (5-95% B, 55 min, 1 ml/min). Detection was performed at 254 and 280 nm and compounds were identified by comparison with authentic standards. Data are presented as mean $\pm$ SD ($n=3$). Differences were assessed by two-way ANOVA, followed by Tukey's test ($p < 0.05$). The IC_{50} and EC_{50} values were calculated by linear regression. IC_{50} and EC_{50} values were calculated by linear regression. Analyses were performed using R 4.0 and the agricolae package (R Core Team, 2020, Mendiburu 2020).

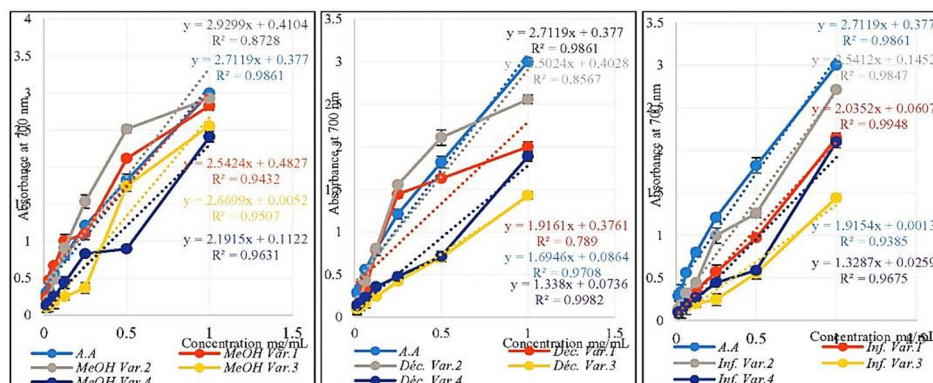
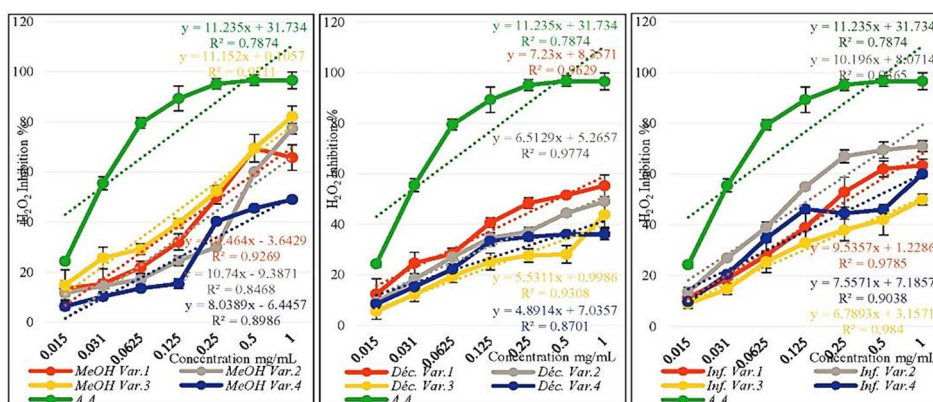
Results and Discussion

Extraction yields varied with variety and method, with the highest yield recorded for the decoction of Breba fig from El Bordj (Dec. var. 3, 11.27%), followed by the infusion of fig from Lahmar (Inf. var.2, 9.45%). Methanolic yields ranged from 5.9 to 8.1% ($p > 0.05$) (Table 1). Phytochemical contents also differed significantly among varieties and extraction methods (Fig. 1). MeOH Var.1 had the highest total polyphenol content (10.4 ± 0.48 mg GAE/g). MeOH var. 2 the highest flavonoid content (1.69 ± 0.15 mg QE/g), and MeOH var. 4 the highest anthocyanin content (0.55 ± 0.09 mg C3G/g). Overall, Lahmar samples, particularly methanolic extracts, showed higher phenolic contents, possibly reflecting the influence of arid environmental conditions on secondary-metabolite production. Antioxidant assays showed significant differences among extracts (Figs 2-5, Table 2). TAA ranged from 151.1 to 481.5 mg AAE/g (MeOH var. 2) showing the highest activity (481.5 ± 11.23 mg AAE/g, $p < 0.05$), DPPH activity was also strongest in methanolic and infused Lahmar extracts, with IC_{50} values of 1.91-3.03 and 2.36-2.55 mg/ml, respectively (Fig. 3). These activities were lower than those of ascorbic acid but were consistent with the higher phenolic and flavonoid contents. The results agree with the reported association between phenolic compounds and antioxidant capacity (Kang *et al.* 2003), while the observed DPPH activity falls within the range reported (0.65-0.82 mg/ml) for other fig varieties (Mujić *et al.* 2012). FRAP confirmed strong reducing activity, particularly in methanolic and infused Lahmar extracts, with low EC_{50} values (Table 2). H_2O_2 scavenging showed a different pattern, with MeOH var. 3 exhibiting the highest inhibition (82.1%, $\text{IC}_{50} = 4.47$ mg/ml), indicating that antioxidant performance varied according to the assay and extraction method. β -carotene bleaching likewise showed significant differences, with MeOH Var.1 providing the highest lipid-peroxidation inhibition (87.5%), followed by Lahmar infusions (Figs 6-7). The strong reducing and lipid-protective activities are consistent with the contribution of flavonoids and other phenolic compounds to antioxidant effects (Chakraborty *et al.* 2012). The β -carotene results are also consistent with previous observations regarding the stability of antioxidant activity during incubation (Kostova 2006). HPLC analysis revealed distinct phenolic profiles among the four methanolic extracts (Table 3). Lahmar fig (var. 2), which showed the strongest overall antioxidant activity, contained gallic acid, catechin, rutin and psoralen, whereas berberine was detected only in El Bordj fig (var. 4). Syringic acid and kaempferol were shared among the extracts. The presence of gallic, syringic and other phenolic compounds agrees with profiles reported for fig cultivars, particularly Bakor-type fruits (Piga *et al.* 2008, Vallejo *et al.* 2012).

Table 1. Dry matter content and extraction yield of *Ficus carica* L. fruits.

Variety (Origin, Fruit Type)	Dry matter content (%)	Yield (%)		
		Methanolic	Aqueous (Decoction)	Aqueous (Infusion)
Var. 1 (Lahmar, Breba fig)	31.1	6.4	7.57	4.89
Var. 2 (Lahmar, fig)	35.6	8.1	8.69	9.45
Var. 3 (El Bordj, Breba fig)	29.3	5.9	11.27	8.65
Var. 4 (El Bordj, fig)	26.4	7.4	7.16	5.55

**Fig. 1.** Total phenolic compound of *F. carica* fruit extracts. MeOH: methanolic extract; Dec: decoction, Inf: infusion, var.1-4: fig varieties, TPT: total polyphenols, TFT: total flavonoids, TAT: total anthocyanins : TTC: total condensed tannins.**Fig. 2.** Total antioxidant activity of *F. carica* fruit extracts. AA: ascorbic acid.**Fig. 3.** DPPH radical scavenging activity of *F. carica* fruit extracts.

Fig. 4. FRAP reducing power of *F. carica* fruit extracts.Fig. 5. H_2O_2 scavenging activity of methanolic *F. carica* fruit extracts.Table 2. Antioxidant activity (IC_{50} and EC_{50} values) of *F. carica* extracts.

Sample	Description	DPPH IC_{50} (mg/ml)	FRAP EC_{50} (mg/ml)	H_2O_2 IC_{50} (mg/ml)
Methanolic Extracts				
MeOH Var.1	Breba fig Lahmar	3.034 ^a	0.006 ^a	5.126 ^a
MeOH Var.2	Fig Lahmar	1.906 ^b	0.030 ^b	5.529 ^a
MeOH Var.3	Breba fig El Bordj	3.528 ^a	0.185 ^d	4.474 ^a
MeOH Var.4	Fig El Bordj	2.585 ^b	0.176 ^d	7.021 ^b
Aqueous (Decoction)				
Dec. Var.1	Breba fig Lahmar	4.361 ^a	0.064 ^a	5.759 ^a
Dec. Var.2	Fig Lahmar	4.102 ^a	0.038 ^b	6.868 ^{ab}
Dec. Var.3	Breba fig El Bordj	5.240 ^b	0.318 ^c	8.859 ^b
Dec. Var.4	Fig El Bordj	6.345 ^b	0.244 ^d	8.783 ^b
Aqueous (Infusion)				
Inf. Var.1	Breba fig Lahmar	2.554 ^a	0.215 ^a	5.114 ^a
Inf. Var.2	Fig Lahmar	2.362 ^a	0.139 ^b	4.112 ^{ab}
Inf. Var.3	Breba fig El Bordj	4.891 ^b	0.356 ^c	6.899 ^b
Inf. Var.4	Fig El Bordj	4.098 ^b	0.260 ^d	5.665 ^a
Positive control				
Ascorbic acid (A.A)	Standard	0.069 ^c	0.045 ^c	1.625 ^c

Different lowercase superscript letters within the same column indicate statistically significant at $p < 0.05$. Values sharing the same letter are not significantly different at $p > 0.05$.

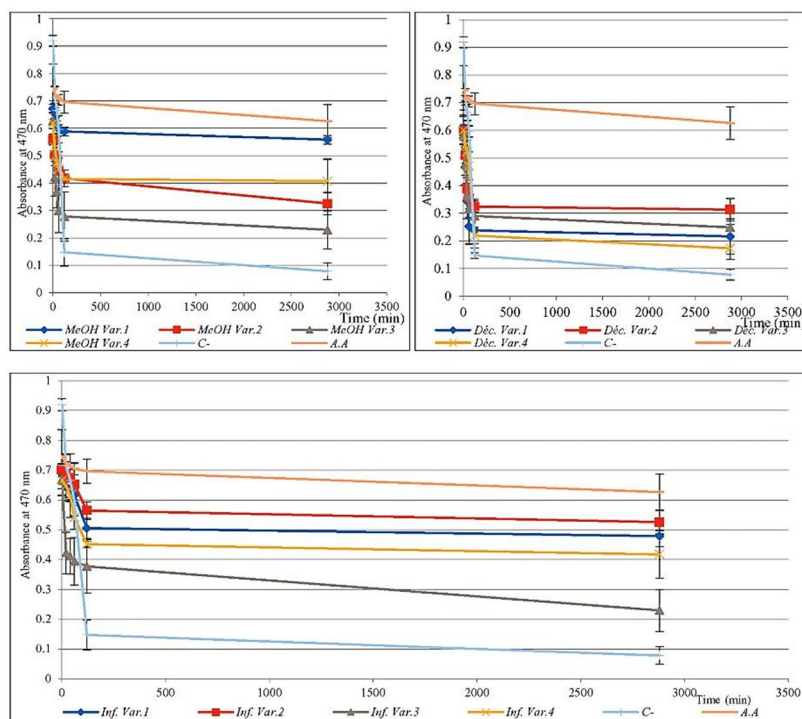
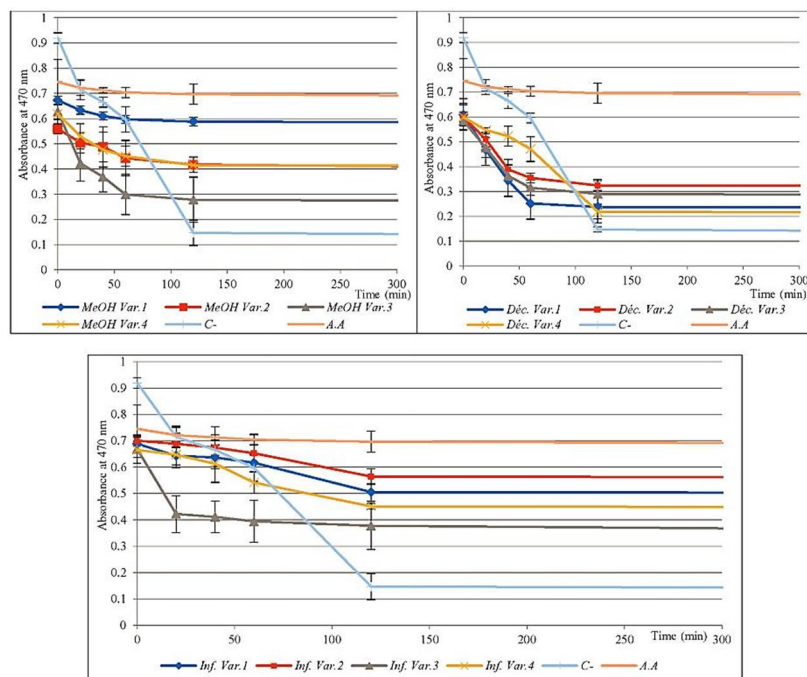

 Fig. 6. β -Carotene bleaching kinetics in the presence of *F. carica* fruit extracts.

 Fig. 7. Initial β -carotene bleaching kinetics in the absence and presence (0-300min).

Table 3. Phenolic compounds of methanolic extracts of *Ficus carica* L.

Compound class	Identified compound	Var.1 Lahmar B	Var.2 Lahmar F	Var.3 El Bordj B	Var.4 El Bordj F
Phenolic acid	Gallic acid		✓		
	Caffeic acid		✓	✓	
	Syringic acid	✓	✓	✓	✓
Flavanols	Catechin		✓		
	Epicatechin	✓	✓		✓
Flavonols	Rutin		✓	✓	
	Quercetin			✓	
	Kaempferol	✓	✓	✓	✓
Others	Psoralen		✓	✓	
	Berberine				✓

B : Breba fig, F: Figue.

The use of decoction and infusion also supports the relevance of traditional aqueous preparations (N'guessan *et al.* 2009). Algerian figs, particularly those from Lahmar, showed substantial phenolic content and antioxidant potential. The association between phenolic composition and antioxidant activity, together with the effectiveness of aqueous preparations, supports their potential as natural antioxidant sources and functional food ingredients.

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